epitiro
The Broadband Communications Authority

Comments - Mobile Broadband Measurement

Reference CG Docket No. 09-158, CC Docket No. 98-170 and

WC Docket No. 04-36

CONTENTS

Federal Communications Commission
445 12th St., S.W.
Washington, D.C. 20554
News Media Information 202 / 418-0500
TTY 202 / 418-2555
Internet: http://www.fcc.gov

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COMMENT SOUGHT ON MEASUREMENT OF
MOBILE BROADBAND NETWORK PERFORMANCE AND COVERAGE
PLEADING CYCLE ESTABLISHED
CG Docket No. 09-158, CC Docket No. 98-170, WC Docket No. 04-36

1. WHAT ARE THE BEST MEASUREMENT METRICS FOR MOBILE BROADBAND SERVICES?

Mobile broadband technologies such as WiMAX, HSPA+ and LTE will increasingly be positioned and sold as direct replacements for fixed broadband services. The move to a world where all services are based on IP technology is leading us to a converged communication and digital media environment where services will be delivered irrespective of the means of access. As such, the FCC should make no distinction between the measurement metrics applied to fixed-line or mobile broadband services. On this basis, the following list, based on the fixed line initiative, outlines the IP measurements that best represent the test requirements for mobile broadband services.

Recommended Key Performance Indicators (KPIs) for Wireless Broadband
Wireless Broadband Service Availability (Packet Domain)
TCP Throughput Speed Down – A precise measurement of link capacity in the downlink
TCP Throughput Speed Up - A precise measurement of link capacity in the downlink
HTTP – Web Browsing Speed (National basket of URLs)
HTTP – Web Browsing Speed (International basket of URLs)
Network Latency (National, US)
Network Latency (International, EUR, ASIA/PAC)
Latency International Server's – Round trip latency – Int'l
Latency Ping International – Summary of Round trip latency – Int'l
DNS Performance including Response times & failures
Network Loss – TCP/UDP Packets lost in transit during testing
Network Jitter – Network Jitter
VoIP MOS – Estimation of Voice over IP call quality when using wireless broadband. This would be based on a range of industry-standard CODECs including *G.711, G.729, SKYPE*
Video MOS – Testing of the network's ability to delivery voice and video sequences over the wireless link. MOS would be based on Jitter, Latency, Frame Loss and Media Delivery Index
Traffic Management Profiling – Net neutrality testing across of a variety of traffic classes including P2P protocols (BitTorrent, LimeWire, etc..)

Table 1. *Recommended Key Performance Indicators (KPI) for Wireless Broadband*

1A. WHAT PERFORMANCE CHARACTERISTICS SHOULD BE TRACKED FOR MOBILE BROADBAND NETWORKS (E.G., TYPICAL DATA, THROUGHPUT, SIGNAL STRENGTH, ACCESSIBILITY, RETAINABILITY, LATENCY, OTHER QUALITY OF SERVICE PARAMETERS)?

A range of environmental characteristics including Radio/Spectral conditions and location-based measurements should be captured alongside the set of IP measurements outlined above. Doing so will ensure that a level of normalization of the data under varying conditions is available to make informed decisions about service and network capability. The following RF & GPS measurements should be captured to correlate the IP measurements;

Radio Frequency (RF) Information - per individual test (Smartphone only)	
Location Area Code (LAC)	Location Area Code for the test
Tower/Cell ID	ID of serving cell for the test
LAC	Location Area Code
RSSI	The Received signal strength Indicator (dBm) for the test fix
CPICH RSCP	The level index of CPICH RSCP of the test
Access Protocol	GPRS, EDGE, UMTS, HSDPA, HSUPA, HSPA, EV-DO, WiMAX, LTE etc...

Table 2. *Radio / Spectral Measurements*

GPS Information	
Latitude	The latitude of the test.
Longitude	The longitude of the test.
Altitude	Altitude of the test.
Speed	Speed of the device over ground in meters/second *(for in-motion testing)*

Table 3. ***Location / GPS information***

AT WHAT LEVEL OF TEMPORAL AND GEOGRAPHIC GRANULARITY?

Epitiro has designed its technology to report on a highly granular basis right down to a street-level detail level. This information, collected via GPS, ensures the presentation of performance and coverage data is in an easy-to-interpret format and is informative and timely as the collection process is automated end-to-end. Doing so allows the information to be aggregated at a higher level (ZIP, City, State, etc..) for reporting if necessary

From a temporal perspective it is important not to overload individual serving towers with unnecessary tests as this will likely degrade the service for others users. To mitigate this Epitiro would assign fixed schedules to devices that ensure an even spread of testing 24x7 but with appropriate intervals between test cycles (e.g. 12/24 x 7). In addition Epitiro recommends a model where the device detects a change of serving tower and uses this event as a potential test-cycle trigger.

1B. WHAT PARTS OF THE NETWORK SHOULD BE MEASURED? WHAT STARTING AND ENDING POINTS (E.G., RADIO ACCESS NETWORK, MIDDLE MILE) ARE MOST USEFUL AND ACTIONABLE FOR CONSUMERS, REGULATORS AND PROVIDERS?

There is only one accurate place to measure the end-to-end performance of the mobile broadband network - the point of delivery to the consumer. For mobile broadband services this is the consumer's broadband-enabled device including both PCs with dongles and broadband-enabled Smartphones.

All tests should start at the user device and terminate beyond the Operator's core network ("last mile") in the public internet. Doing so provides an accurate and clear indication of the performance levels Consumers are actually experiencing.

1C. SHOULD MEASUREMENT PROCESSES AND STANDARDS FOR MOBILE BROADBAND SERVICES BE DIFFERENT THAN THOSE FOR FIXED BROADBAND CONNECTIONS?

No. As next generations mobile broadband technologies including WiMAX and 3GPP LTE become pervasive, Mobile broadband service will be purchased as a direct replacement for fixed broadband services. As such, the set of measurement processes and standards should be the same in so far as is feasible.

2. WHAT ARE THE BEST METHODS FOR COLLECTING DATA ON MOBILE BROADBAND PERFORMANCE AND COVERAGE FOR END-USERS?

The correct answer depends on the measurement tasks identified. In the life-cycle of any network, there will be a range of network quality measurement needs.

During network deployment, radio optimization metrics are vitally important. Post-deployment Operators should be more concerned about competitive benchmarking, network optimization and Quality of Service (QoS) KPIs.

In addition there are circumstances when a combination of tools, used on the same project, can deliver far more value than the use of one tool type on its own – the concept of a measurement "tool kit" to cover the range of deployment scenarios. Such a tool kit should ideally:

- Have a sufficient range of options to cover both current and future needs
- Provide standard underlying measurements across all deployment models
- Provide common analysis software to allow valid comparisons

This will allow the optimal balance between cost and the long term effectiveness of the measurement program.

2A. WHAT ARE THE BEST AVAILABLE TOOLS IN THE MARKET TODAY FOR MEASURING MOBILE BROADBAND PERFORMANCE AND SERVICE COVERAGE?

There are many Vendors in the market place offering Mobile Testing equipment. Many of these vendors offer specialized tools for individual aspects of the measurement portfolio. The most comprehensive and scalable tool-set available for the combined requirements of this project, including RF measurements, location & positioning and all the outlined broadband-specific measurements is Epitiro's **IPQ** tool set. The solution combines software for both Smartphone and Dongle-based PCs and provide all the measurements necessary to provide a comprehensive and statistically relevant sampling size in an economical way.

2B. ARE THERE CURRENT DATA SETS ALREADY AVAILABLE THAT COULD BE USEFUL FOR FACILITATING BETTER CONSUMER DISCLOSURES ON MOBILE BROADBAND PERFORMANCE AND COVERAGE?

Epitiro is not aware of any existing North American data sets that freely provide a single repository of information covering both wireless broadband data and related performance information to consumers. There are vendors who provide coverage maps and there are Operator-specific "coverage only" maps available from some of the leading operators such as AT&T, Verizon and others.

AT&T
http://www.wireless.att.com/coverageviewer/#?type=data

Verizon
http://phones.verizonwireless.com/3g/

2C. ARE THERE EXISTING TECHNOLOGIES THAT CAN MEASURE ACTUAL END-USER EXPERIENCE ON MOBILE BROADBAND NETWORKS?

Yes. Epitiro provides a suite of tools that provide measurement and coverage information from Dongle-based PCs and a growing range of Smartphone. This technology, known as IPQ, provides scalable, real-time performance information and KPIs on the all aspects of mobile broadband performance from the Dongle-based PCs and Consumer Smartphones

IF SO WHERE COULD THE MEASUREMENTS TAKE PLACE (E.G., ON THE DEVICE, INSIDE THE NETWORK)?

Epitiro's focus is on accurately measuring end-to-end performance, starting on the device and measure beyond the "last mile" to well-peered termination points. Our attitude is that "in network" measurement can be useful for root-cause analysis and Operator-focus network operations but the only accurate place for a true understanding of end-to-end performance is from the Consumer's device(s).

Figure 1. *IPQ - End-to-End Testing starts on the device*

"Crowd-sourcing" and user-device level data is fundamental to collecting statically relevant and accurate coverage and performance data in an economical way. By making testing software for both Smartphone and Dongle-based PCs available to large scale "opt in" and pre-designed commercial panels we can move closer to ubiquitous national coverage and get more accurate and statistically-relevant data.

Epitiro has previously partnered with several established, panel-based market research companies to provide ongoing recruitment of a representative sample of Internet users. Examples include **Nielsen** (USA, New Zealand) and **YouGov** (UK on behalf of **Ofcom** for similar ongoing national study of Wireless broadband). By partnering with existing market research panels, the recruitment process is able to reach a large and diverse group of panelists from all demographic groups and in all Internet usage locations.

3A. WHAT EFFORTS AND TECHNOLOGIES CURRENTLY EXIST THAT CAN ENABLE DEVICE LEVEL DATA COLLECTION ON PERFORMANCE AND COVERAGE OF MOBILE BROADBAND NETWORKS? WHAT METRICS COULD A DEVICE LEVEL SOFTWARE APPLICATION COLLECT THAT COULD MEASURE MOBILE BROADBAND PERFORMANCE AND COVERAGE (E.G., SIGNAL STRENGTH, DATA, THROUGHPUT RATE)?

Epitiro's **IPQ** technology provides autonomous data collection at device level for RF and IP-based measurement.

The **IPQ** software is quickly and easily deployed on any Windows PC with a broadband dongle attached or any supported Smartphone.

Figure 2. *Epitiro's IPQ tests directly from mobile handsets consumer PCs*

Once on the device the software operates unobtrusively according to a defined set of instructions defined by the Operator or Regulator. These instructions can include a vast range host of location, RF and IP-based measurements and each can be driven by a variety of events. Once activated, IPQ performs its measurements automatically and unobtrusively, with no further actions required. The software can also be remotely de-activated on demand.

WHAT OTHER DATA POINTS WOULD BE VALUABLE TO COLLECT IN ASSOCIATION WITH THAT DATA (E.G. LOCATION, TOWER ID, HANDSET TYPE)?

Epitiro recommend collecting location (GPS), Environmental and Spectral (RF) , Device type and capabilities and a considerable range of broadband measurement (TCP, UDP, HTTP, FTP, etc...)
3b. For collecting device level data, what impact does the type of device (e.g., Smartphone, feature phones, laptop, wireless modem) itself have on end-user experienced network performance?

Epitiro collect device-specific information from both Dongle and Smartphone-based panels.

Dongles
Epitiro have noted significant variations in the choice of dongles used to access the various wireless networks. Our attitude to this is that these are generally the devices the MNO has provided and should be recorded and reported as such.

Smartphones
The latest Smartphones devices are capable of supporting speeds well in excess of those the networks are capable of delivering (i.e. HSUPA at 7.2Mb downlink, 2.0Mb uplink). It is however important to log and record all such device level information for normalization of data if required.

3.1 HOW, IF AT ALL, COULD A MEASUREMENT METHODOLOGY TAKES VARIATIONS RESULTING FROM DEVICE TYPE INTO CONSIDERATION?

This is perfectly feasible and something Epitiro does today. By recording the underlying device information (Type, Manufacturer, S/W Version, Model Release Information) Epitiro is able to mandate for known issues on certain devices and remove this data from any final reporting.

3.1.C. HOW COULD MEASUREMENT METHODOLOGY ACCOUNT FOR VARIATIONS IN PERFORMANCE DUE TO THE LOCATION (E.G. BASEMENT OF HOUSE VS. ABOVE GROUND) OR MOVEMENT (E.G. USER ON A TRAIN) OF THE END-USER?

This is perfectly feasible. By recording radio characteristics (RSSI, CPICH RSCP) and GPS information Epitiro can determine if the testing takes place in such scenarios where signal quality is low and also determine if the test device was in-motion during a test and discount the results if appropriate. This is technically feasible – it's more a question of deciding what the requirements are in such scenarios and act accordingly. Epitiro is able to mandate for such environmental variances and include/exclude this data as required from any final reporting.

HOW CAN WE ACCOUNT FOR DIFFERENCES IN LOCATION DETERMINATION METHODS (E.G. GPS) ACROSS HANDSETS AND PROVIDERS, IF ANY?

There are two options which Epitiro utilizes today. One is fine-grained and based on getting a GPS fix where relevant – this provides accuracy to within meters (yards). The other option, where GPS is not available, is to use a course-grained approach – using the serving tower ID and neighboring towers and triangulating to estimate a position.

HOW SHOULD BUILDINGS, TOPOGRAPHY, WEATHER, CONTINUED NETWORK BUILD-OUTS, AND OTHER SERVICE-AVAILABILITY VARIABLES BE ACCOUNTED FOR IN THE METHODOLOGY?

On-going testing and always providing timely (near real-time) access to the data recorded will mitigate environmental factors and also accurately reflect on-going investments in network infrastructure.

3D. CAN A STATISTICALLY ROBUST SAMPLING METHOD CORRECT FOR THE VARIABLES DESCRIBED ABOVE, SUCH AS THE IMPACT ON PERFORMANCE AND COVERAGE MEASUREMENTS OF MOVEMENT, DEVICE AND LOCATION VARIABILITY?

There is scope for statistically robust sampling to impact the experience of others users and generally degrade the network's capacity with active testing method if the scheduling model is not sufficiently intelligent.

3E. HOW CAN WE MEASURE PERFORMANCE WITH MINIMAL IMPACT ON THE NETWORK ITSELF? FOR EXAMPLE, HOW CAN ACTIVE MEASUREMENT TECHNIQUES THAT GENERATE ADDITIONAL NETWORK TRAFFIC MITIGATE POTENTIAL INCREASES IN CONGESTION?

Backhaul contention is the single biggest issue in 3G & 4G networks today. Epitiro's advanced testing algorithm mitigates the impact on the network's resources, including backhaul, whilst also providing the necessary data and coverage to provide accurate and statistically robust measurements.

Each device is configured to pre-check various environmental factors and recent activities before beginning its set of tests. They key to this algorithm is in knowing when a serving tower/cell was previously tested and to maintain a test profile that mitigates congestion or over-testing. By defining a minimum test interval for each tower Epitiro can ensure that no single tower is tested more than once during any pre-defined period of time. In such circumstances, even with '000s of subscribers on the same tower, it would only be subjected to testing once per pre-defined interval.

4. WHAT ARE THE BENEFITS AND COSTS OF MEASUREMENT FOR PROVIDERS, REGULATORS, CUSTOMERS AND OTHERS?

The benefits of understanding coverage and related broadband capability on a nationwide basis are clear to each user segment.

Providers
By providing comprehensive real-time information on coverage and performance Operators can understand where investment is most needed to improve the quality of service for their customers.

Regulators
By driving the process Regulators can ensure that Operators are making the necessary infrastructure investments to ensure Customer satisfaction – a key role for the FCC. This will help to cultivate a vibrant and competitive telecoms industry for America.

Customers
By providing coverage maps and related broadband performance and regional benchmarks Customers will be better informed and in a much stronger position to decide which network and related service best suits their needs.

Costs
The scope for costs associated with a project of this scale can vary enormously dependent on the measurement models chosen, but experience suggests that using “crowd-sourcing“ models, with software deployed on Consumer Smartphones and PCs, based on “opt-in” panels, will provide an accurate, statistically robust and cost-effective solution.

4A. WHAT ARE THE BENEFITS (E.G., TRANSPARENCY, BETTER DATA, NETWORK AND INTERNATIONAL COMPARABILITY, BENEFITS FOR RESEARCHERS, VERIFICATION OF NATIONAL BROADBAND MAP GRANTEE DATA)?

Access to this information will benefit researchers, institutions, nations and society as a whole. For researchers, it brings increased visibility, usage and impact for their work. There is growing evidence to show that countries also benefit because access to this information increases the impact of the research and provides a strong return on investment. Society as a whole benefits as empirical research is more accurate and effective, and will lead to better network services for everyone. The benefits of the proposed data collection fall into a number of key categories that will allow for more detailed and empirical data for Exploratory, Descriptive, Predictive and Conclusive research.

- **Exploratory research** - pertaining to research that investigates assumptions
- **Descriptive research** - which as the label suggests, describes "what is"
- **Predictive research** - conducted to predict a future occurrence
- **Conclusive research** - beneficial for the purpose of deriving a conclusion via a research process.

A well formed FCC-driven project in the area of wireless broadband will clearly facilitate all of the research areas outlined above. In addition, this US-specific data can be aligned to other International data on performance globally to drive investment and on-going network improvements.

4B. WHAT ARE THE COSTS (E.G., HARDWARE COSTS, USAGE OF THE NETWORK, CONSUMER HASSLE, ACCURATE INFORMATION ALREADY EXISTS)?

The costs for such a project are clearly divided between panel recruitment (using a market research professional) and the costs of test and reporting infrastructure and bandwidth at peering points beyond the core mobile network to terminate testing.

Once the panelist has downloaded the software over-the-air the testing becomes autonomous with little or no further interaction required by the Customer.

The costs are effectively linear in relation to the size of the consumer panel. In the first instance, Epitiro would recommend a statistical analysis of the market to define an appropriate and statistically relevant sample size or this project. Once complete a clear and accurate picture of cost can be formed.

4C. ARE THERE ANY LEGAL, SECURITY, PRIVACY OR DATA SENSITIVITY ISSUES WITH COLLECTING DEVICE LEVEL DATA? IF SO, HOW CAN THESE ISSUES BE ADDRESSED?

In our experience, the key issue is managing and maintaining strictest privacy for any personally identifiable information (PII). To avoid any legal, privacy or data sensitivity issues Epitiro will generally recommend partnering with an established panel-based market research companies to provide representative panels of users willing to download the necessary software to their devices. By partnering in this way, the recruitment process is able to reach a large and diverse group of panelists from all demographic groups and in all wireless broadband locations and provides a clean separation or firewall between performance data and any PII data. Epitiro are considered experts in collecting performance data and Epitiro would select a third-party market research company who are experts in panel selection and data privacy and security. Also suggested is a sample recruitment and management process that follows the guidelines below.

- All panelists to be queried on a strict opt-in basis after having been provided meaningful notice
- The provision of a clear Privacy Policy and Panel Membership Agreement before any data collection
- Privacy Policy always available in a clear and conspicuous position on website, and, depending on the type of measurement channel, accessible from the relevant device, to continually remind panelists of their data privacy rights
- Never uses panel participant information to advertise, promote or market third party goods to panel members
- Always aggregates or de-identifies panelist data when reported to third parties.
- Never provides panelists' personally identifiable information ("PII") to third parties
- Ensure security measures in place (including encryption methods and access protocols) to help
- protect the security and confidentiality of PII;
- Ensure panelists can correct their PII data at any time;
- Permits panelists to resign from panels at any time and remove their personally-identifiable information from its databases;

Epitiro would recommend providing easily understood benchmark and coverage reports on a national and regional level. These reports should cover all aspects of coverage and performance of the networks. Doing so would enable consumers to make informed decisions as to which service or services they should subscribe to at a local, regional or national level.

5A. WHAT ARE THE CURRENT BEST PRACTICES FOR DISPLAYING OR COMMUNICATING MOBILE BROADBAND PERFORMANCE AND COVERAGE TO CONSUMERS TODAY?

Epitiro's work and experience with some of the leading Telecoms regulators around the World suggests that the best way to provide data is online – using Regulatory portals that communicate clear and concise information about the data in near real-time. A clear example of this model is available here: http://www.ida.gov.sg/Publications/20061213184450.aspx

This portal provides a range of key performance indicators for broadband services as provided by the leading Operators in the country. Epitiro's data is provided on an ongoing basis 24x7x365. Reported metrics include:

- Download Throughput (National)
- Upload Throughput (National)
- Download Throughput (International to the USA)
- Upload Throughput (International to the USA)
- Latency (National)
- Latency (International)

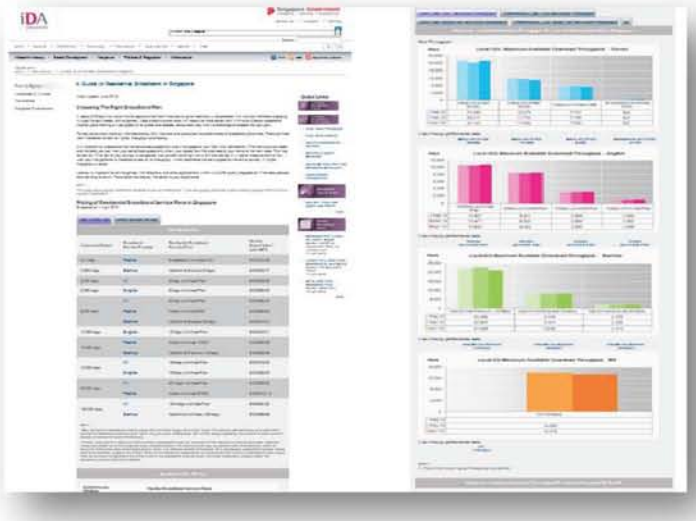


Figure 3. *Sample: Singapore IDA National Performance Data*

This data is provided by Epitiro in real-time to the Regulatory Authority and made available online on a per-Operator and Benchmarked basis.

5B. ARE CONSUMERS CURRENTLY BEING PROVIDED WITH ENOUGH ACCURATE AND DETAILED INFORMATION ABOUT PERFORMANCE AND SERVICE COVERAGE TO MAKE INFORMED CHOICES BETWEEN DIFFERENT MOBILE BROADBAND NETWORK PROVIDERS?

Given Epitiro's global perspective the company would suggest that in some countries, with strong regulatory activity, there is growing levels of information being made available to consumer to make informed decisions. Epitiro has recently been contracted by a number of Regulatory bodies worldwide to provide more detailed information on Wireless broadband performance and coverage. These include:

- **OFCOM:** Ofcom, the UK Regulator, is an independent organization which regulates the UK's broadcasting, telecommunications and wireless communications sectors. Ofcom has recently selected Epitiro to implement a detailed nationwide study of wireless broadband service across the UK.

- **Kingdom of Bahrain Telecoms Regulatory Authority (TRA):** The Telecommunications Regulatory Authority (TRA) was established by Legislative Decree promulgating the Telecommunications Law. The TRA is an independent body and its duties and powers include protecting the interests of subscribers and users, and promoting effective and fair competition among established and new licensed operators. Epitiro have been providing robust data on the performance of Wireless broadband services in the Kingdom for a number of years. Services tested include 2G/3G and WiMAX broadband services

- **The InfoComm Development Authority of Singapore (IDA):** Singapore's infocomm sector is a key contributor to its economy. Revenues for the infocomm industry hit S$58.1 billion. Infocomm has greatly enhanced Singapore's competitiveness by raising productivity and transforming business processes. For five consecutive years, Singapore has been in the top three positions in the World Economic Forum's Global IT Report. In the latest ranking, Singapore was ranked fourth globally. Epitiro have been providing information on both Fixed and Wireless broadband services for a number of years

Current mobile broadband network performance and coverage disclosures: Existing voluntary disclosures related to mobile broadband performance and coverage have proven valuable for consumers. Providers of mobile broadband services usually provide coverage maps and 'up-to' or 'typical' data throughput rates. Third-parties also provide and compile coverage maps for providers (American Roamer) and consumers (Root Wireless). While existing data on mobile broadband services are helpful, gaps remain. For example, the currently provided 'up-to' or 'typical' data throughput rates are rough estimations of actual performance and some coverage maps provide a binary 'yes' or 'no' reading without accounting for signal strength at particular locations, whereas other maps provide more layered readings (such as indoor/outdoor or 'good'/'better'/'best'). Additional voluntary performance measurements and standards could provide better information enabling consumers to make informed choices about mobile broadband services.

6. WHAT MEASUREMENTS ARE TYPICALLY PERFORMED BY SERVICE PROVIDERS TODAY TO TRACK MOBILE BROADBAND NETWORK PERFORMANCE AND SERVICE AVAILABILITY?

Operators utilize data collected from their Base-station/Towers to understand some aspects of performance. There are also systems deployed for drive testing campaigns to provide service coverage and performance analysis.

6A. WHAT TOOLS ARE CURRENTLY AVAILABLE FOR CONSUMERS TO CHECK COVERAGE AND PERFORMANCE AT A SPECIFIC GEOGRAPHIC LOCATION BY MOBILE BROADBAND NETWORK (E.G., COVERAGE MAPS), AND HOW ACCURATE ARE THE DATA FOR TYPICAL OUTDOOR AND INDOOR CONSUMER USE?

Epitiro is not aware of any US-specific tools available to consumers today to check *both* coverage and performance. Epitiro does however provide a range of online reporting mechanisms to many of our Regulatory customers in other countries today.

6B. HOW ARE DATA FOR COVERAGE AND SERVICE AREA MAPS COLLECTED, VERIFIED AND DISPLAYED (HOW COMPILED, HOW ACCURATE, HOW GRANULAR)?

Epitiro's model for collection and reporting is based on real-time collection of all metrics and the company has developed highly-scalable online systems for delivering this captured data in easily understood graphical formats. As Epitiro collects data on Consumer devices there is the capability to report data per individual device or by aggregated views based on network of geographical views and benchmark.

HOW ARE DATA ON MOBILE BROADBAND PERFORMANCE (I.E., DATA THROUGHPUT RATES) MEASURED AND DISPLAYED?

All measurements need to be beyond the core network of the MNOs being tested. Typically a common range of termination servers, deployed at National Network peering points, would provide the most accurate and balanced data

Epitiro recommends the provision of a number of standard reporting models to present data, each driven by the particular requirement or range of users. From a consumer perspective Epitiro would recommend standard map-based reports with regional drill-down capability to a user place of domicile. From a regulatory perspective Epitiro would envisage access to raw data (in raw text, MS-Access or Excel formats) and high-level aggregations at an operator, regional or competitor level. In addition, dials-based views of KPIs is also useful for Network Operations personnel. Examples of each are as follows:

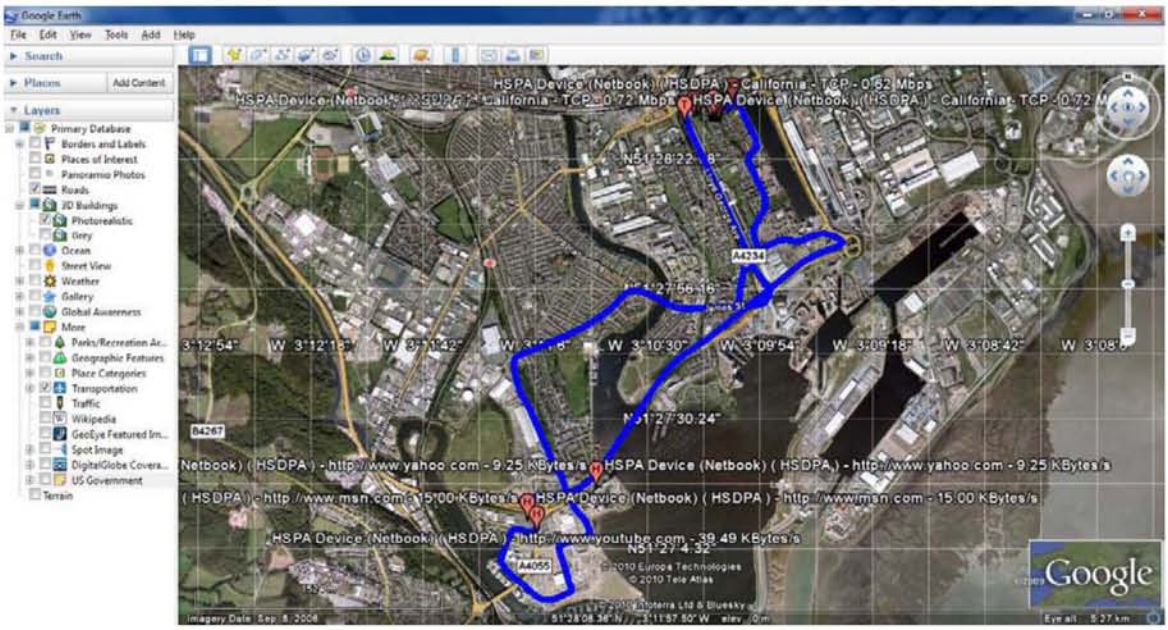
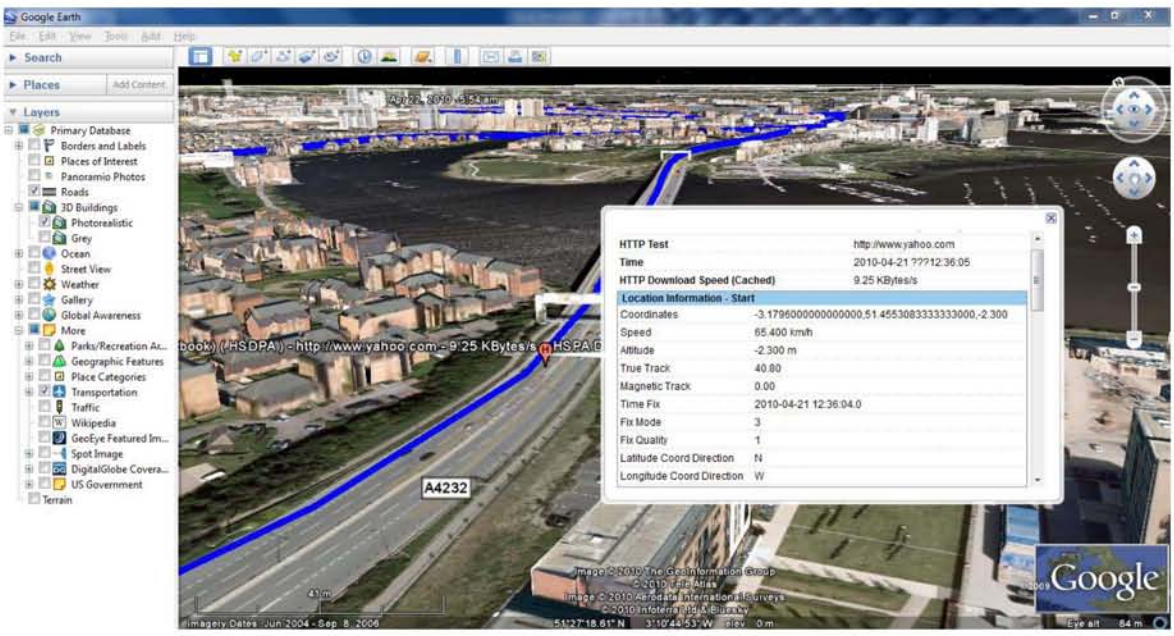


Figure 4. *Mapping-based view of Coverage and broadband capability in single google map report with drill-down and detailed metrics views*



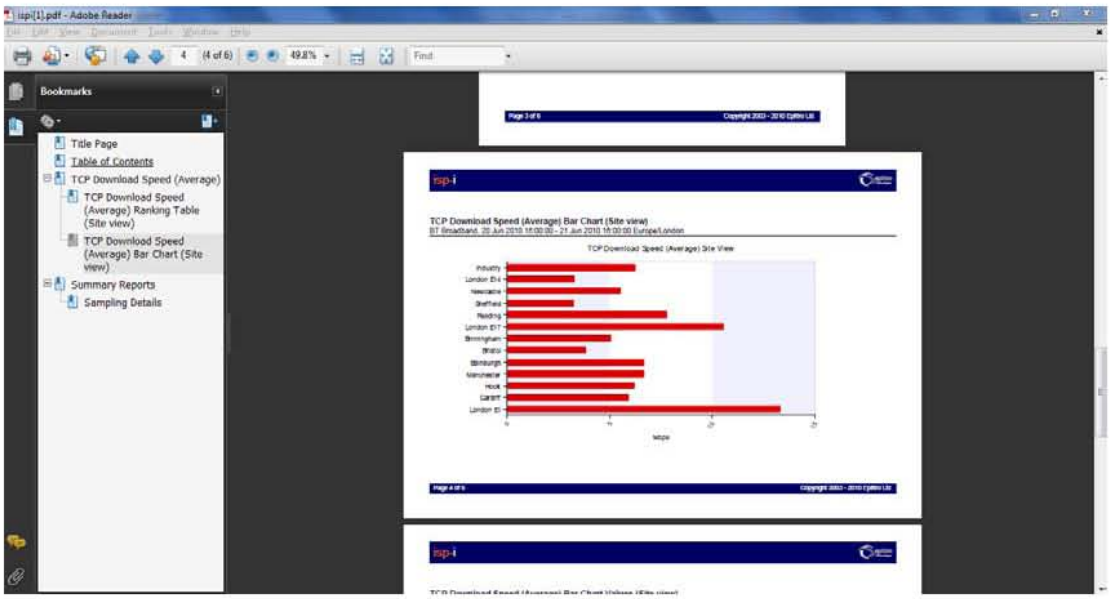


Figure 5. *PDF-based report*

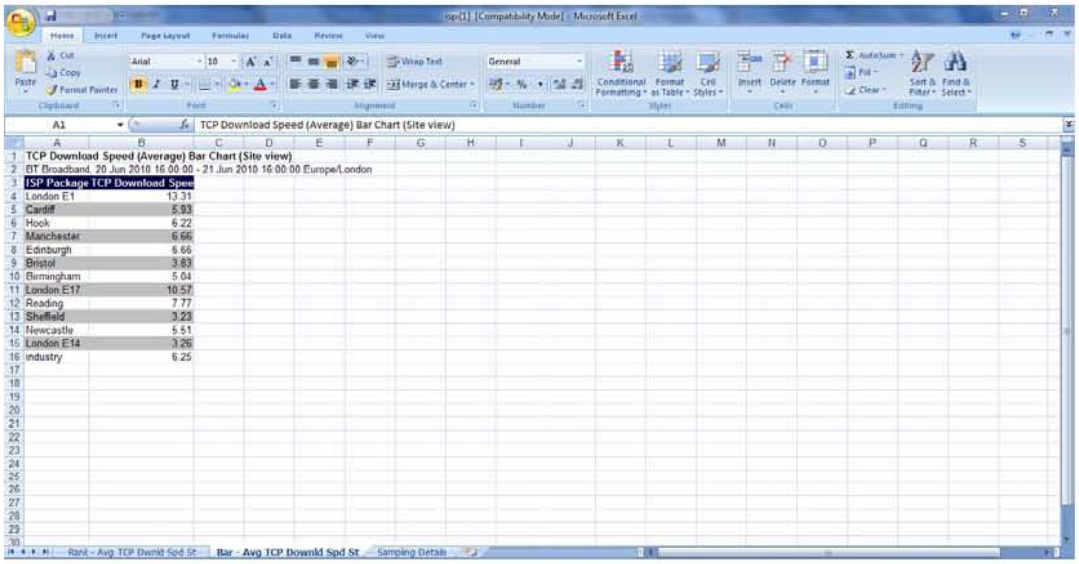


Figure 6. *Excel-based view*

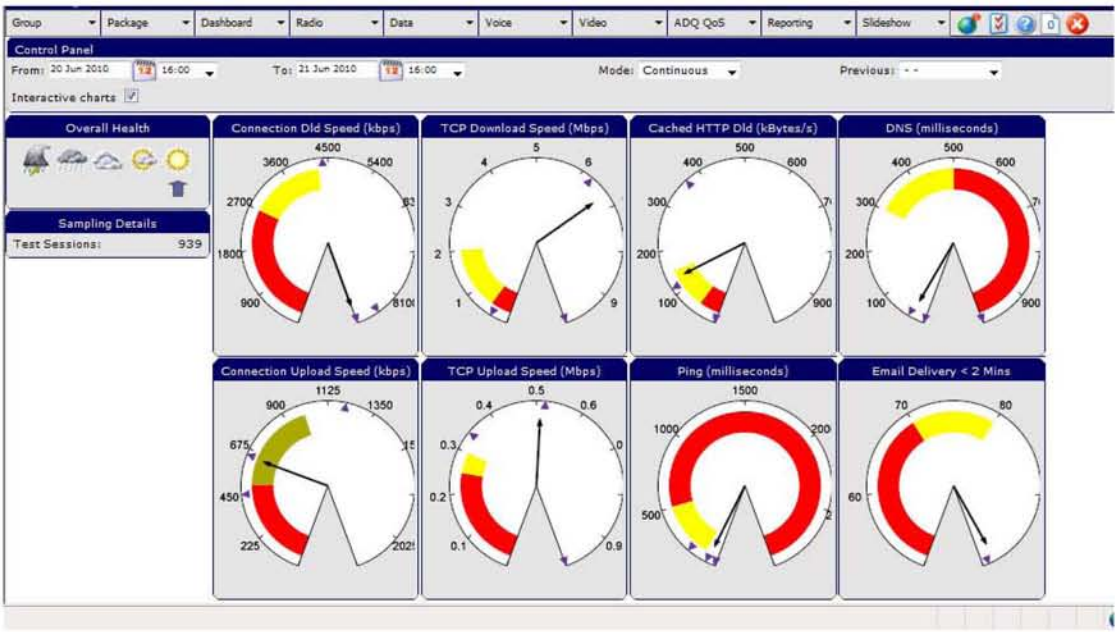


Figure 7. *Dials-based view of KPIs*

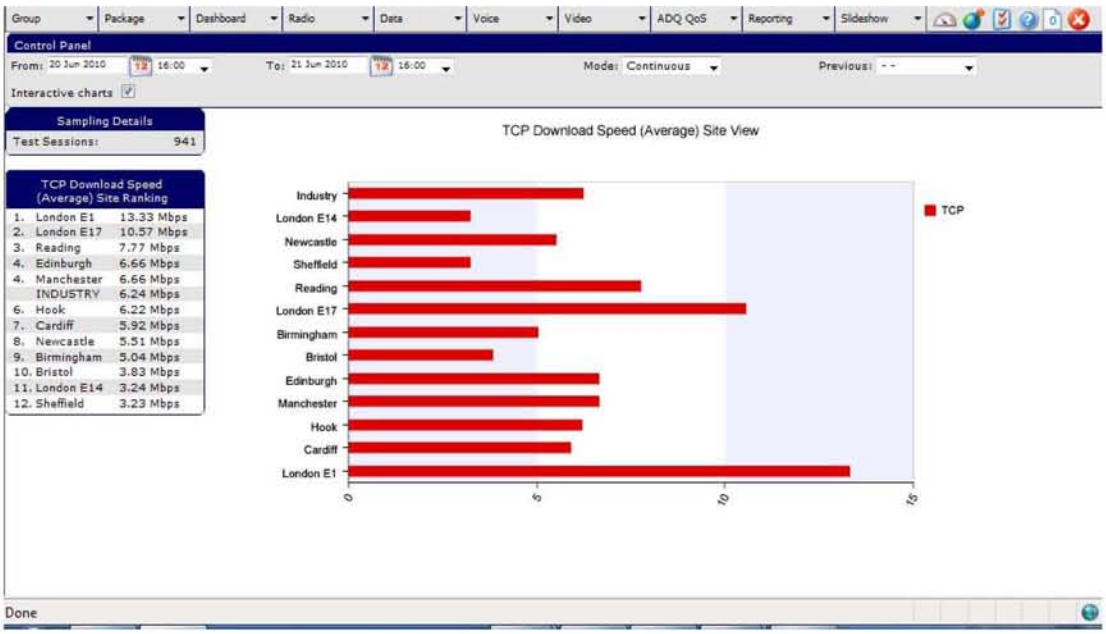


Figure 8. *Line Chart view of Regional Benchmark - average download speed*

6C. WHAT TECHNOLOGIES ARE USED TO COLLECT SUCH DATA (E.G., RF MODELLED COVERAGE, DRIVE TESTS, NETWORK REPORTING, HANDSET DATA COLLECTIONS)?

Epitiro would expect that a range of technologies would be required to analyze the different usage patterns and modes available. As previously stated, the concept of a measurement "tool kit" to cover the range of deployment scenarios would be optimal. Such a tool kit should ideally:

- Have a sufficient range of options to cover both current and future needs
- Provide standard underlying measurements across all deployment models
- Provide common analysis software to allow valid comparisons

This will allow the optimal balance between cost and the long term effectiveness of the measurement program. Epitiro would recommend a standard test software capability be deployed to PC-based computers utilizing dongles, drive-testing in key urban and rural areas and, most importantly, handset-based reporting from a range of consumer Smartphone, illustrated as follows;

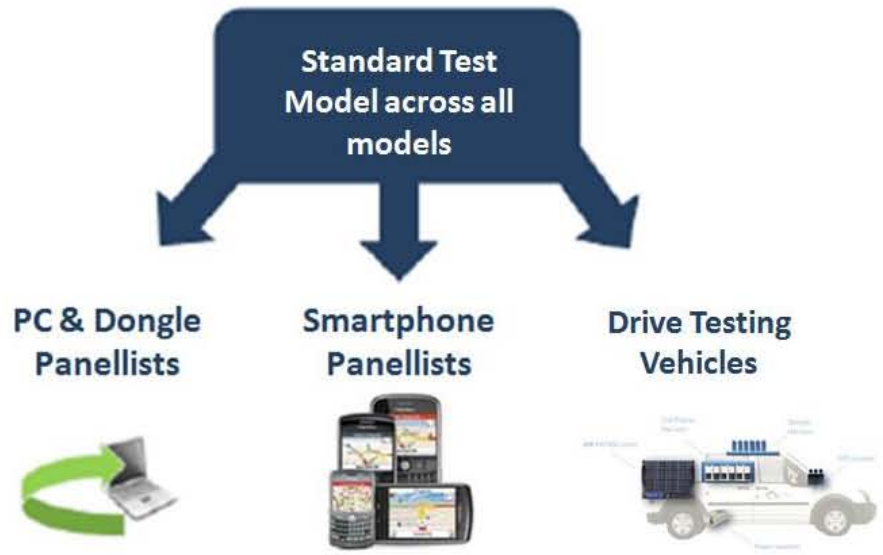


Figure 9. *Common Test for each device type*

6D. ARE THERE ANY VOLUNTARY INDUSTRY STANDARDS THAT ARE BEING USED IN DISCLOSING MOBILE BROADBAND NETWORK PERFORMANCE AND COVERAGE TO CONSUMERS? HOW COULD THESE BE IMPROVED (E.G., SIGNAL STRENGTH OR THROUGHPUT BANDS TO MAP DIFFERENT LEVELS OF SERVICE QUALITY)?

Epitiro is not aware of any International Consumer-focused standards for disclosing mobile broadband network performance. Consumers are familiar with the basic concepts of signal strength and download/upload rates due to general usage and media campaigns.

RESPONSE - ADDITIONAL INFORMATION

Epitiro has conducted similar analysis projects and includes the following reports for review by the FCC;

- UK Mobile Broadband Analysis
- Ireland Internet Performance Index
- Australian Internet Performance Index
- New Zealand Commerce Commission Quarterly Report

Epitiro (UK) Ltd
10/11 Raleigh Walk
Waterfront 2000
Brigantine Place
Cardiff
CF10 4LN

www.epitiro.com